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*Publication date:*  
2015

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Bauer-Gottwein, P., Schneider, R., & Davidsen, C. (2015). *Optimizing wellfield operation in a variable power price regime*. Abstract from 9th Annual Danish Water Research Meeting 2015, Copenhagen, Denmark.

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# Optimizing wellfield operation in a variable power price regime

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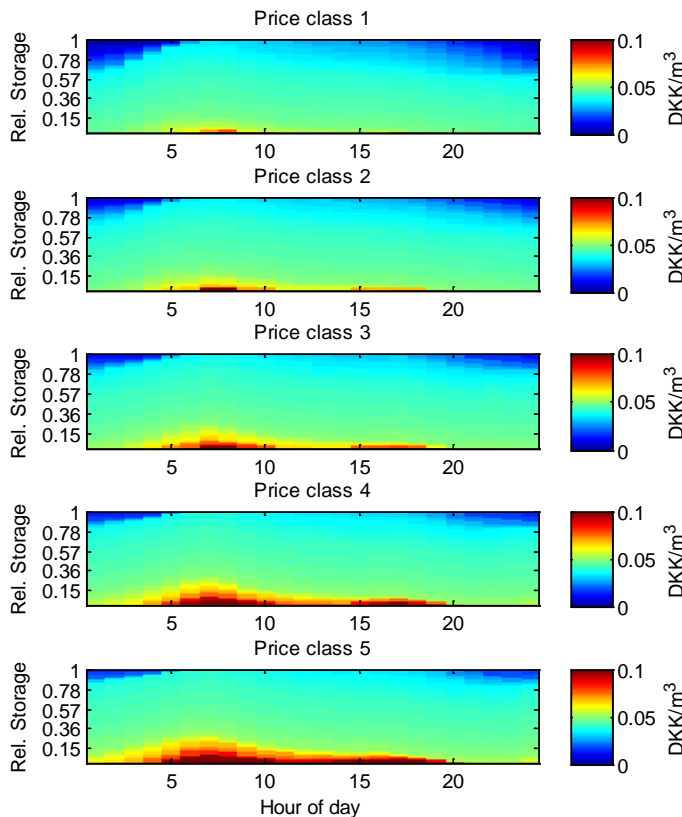
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## Abstract

Wellfield management is a multi-objective optimization problem. One important management objective has been energy efficiency in terms of minimizing the energy footprint (EFP) of delivered water (MWh/m<sup>3</sup>). However, power systems in most countries are moving in the direction of deregulated power markets and power price variability is increasing in many markets because of increased penetration of intermittent renewable power sources. In this context the relevant management objective becomes minimizing the cost of energy used for pumping and distribution of groundwater rather than minimizing energy use itself.

We estimated energy footprint as a function of wellfield pumping rate (EFP-Q relationship) for a wellfield in Denmark using a coupled well and pipe network model. This EFP-Q relationship was subsequently used in a stochastic dynamic programming framework to minimize total cost of operating the combined wellfield-storage-demand system over the course of a 2-year planning period based on a time series of observed price on the Danish power market and a deterministic, time-varying hourly water demand. In the SDP setup, hourly pumping rates are the decision variables. Constraints include storage capacity and hourly water demand fulfilment. The SDP was solved for a baseline situation and for four scenario runs representing different EFP-Q relationships and different maximum wellfield pumping rates.

Savings were quantified as differences in total cost between the scenario and a constant-rate pumping policy. Minor savings up to 10% were found in the baseline scenario, while the scenario with constant EFP and unlimited pumping rate resulted in savings up to 40%. Key factors determining potential cost savings obtained by flexible wellfield operation under a variable power price regime are the shape of the EFP-Q relationship, the maximum feasible pumping rate and the capacity of available storage facilities.



Value of water pumped into storage for every price class, every hour of the day and every storage level